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Battelle Technical Review

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Promise of Biochemical Research

DEVELOPMENT ENGINEER

ROBERT M. CONKLIN

The modern mechanical engineer need not be a master mechanic. It is much more important for him to have imagination and ingenuity combined with a sound technical background. Robert M. Conklin, who directs Battelle's mechanical engineering research, is such a man. A member of the Institute's staff since 1946, Bob began to work as a development engineer after graduation from The Ohio State University in 1938. He began applying his ideas first to the design of baking machinery and then to the development of automatic business machines. For six years prior to joining Battelle, Bob was associated with the Western Electric Company. There he was engaged in the development of automatic production equipment, the study of manufacturing techniques, and the preparation of production machine designs.

According to Bob, design and development engineering has become more scientific with progress in other technical fields. The modern designer has a host of new materials and manufacturing techniques at his command. To contrive today's machines, he must apply such technologies as electronics, metallurgy, physics, chemistry, and ceramics, to name only a few. Cooperation with specialists in fields other than mechanical engineering and coordination of their contributions are essential if maximum benefits are to result from design and development work.

During the past 15 years, Bob's efforts have resulted in over a score of patents in such widely diverse fields as hydraulics, automatic controls, production and manufacturing equipment, new product designs, and unique instrumentation apparatus.

His accomplishments in his field make Bob a valuable member of the American Society of Mechanical Engineers. He is a member of the Executive Committee of the Society's Machine Design Division and Chairman of the Meetings Committee.

Away from his work, Bob is a golfer, hunter, and fisherman. He will soon be teaching these hobbies to his seven-year-old son.

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The Technological Revolution

TO EXPLAIN COMPLEX series of social changes, historians look for the basic causative forces behind those changes. Thus, many of the social upheavals, economic disturbances, and mass actions of peoples in the past two centuries can be related to growth of population and the industrialization of societies that were previously mostly agrarian. We say that this period in human history was dominated by the Industrial Revolution. The Industrial Revolution started with the application of mechanical energy and has continued on an accelerating scale as new and better machines have been developed.

Looking back over the past quarter century, it seems obvious that as industrialization has progressed, and as an essential part of it, a new force has gained dominating influence in the affairs of men, particularly in western cultures. This force is science and technology. We are now experiencing a Technological Revolution which directly or indirectly is affecting everything we do. It is a tide that is sweeping at increasing speed and one that is irreversible. We can consciously aid or abet its progress, but we can not deflect it without disastrous results.

The Technological Revolution began to be felt in the United States shortly after World War I, when industry here turned to science for the answers to its problems. The erratic events we have experienced in the past 30 to 40 years may be interpreted by future historians as the birth pangs of the technological era. We know for certain that the economic system of the United States in this period has changed from one based upon rich natural resources to one based primarily upon science and technology.

In the United States, World War II threw the developing technological pattern into high gear. Research, the best index to the progress of the Revolution, rose from a national total of about $160 million in 1930 to $800 million in 1941, $1.3 billion in 1945, and $3 billion last year. The Technological Revolution is now all-powerful in this country. Application of technology in Europe preceded that in the United States, but it was largely interrupted by World War II and the havoc wreaked upon the material resources and institutions there. No doubt the Technological Revolution will take over as the dominating force in Europe once the physical plant and institutions there have been restored.

The Technological Revolution is a revolution in every sense of the word, and a proper understanding of it is vital to the planning and well-being of every industry. Most American enterprises have sensed what has happened and are exploiting the opportunities offered by technology. These are rising to new heights of achievement, prosperity, and service. Some, however, are still looking with backward glances at past glories and are stumbling at the threshold of new opportunities. Experience of the last few years indicates that the time is ripe now for expansive thinking and bold venturing.

Because of the Revolution, there is real hope that problems of the world heretofore unsolved will be mastered. Industry in the United States, revolutionized by technology, is already building the material foundations for better living and world peace. Soon industry in Europe may be humming a harmonic chord. As the Revolution proceeds, we may see many of the highest ideals of man brought to realization.

Clyde Williams

Director, Battelle Memorial Institute

Promise of Biophysical Research

by RADCLIFFE F. ROBINSON

The author, who joined Battelle in 1942, now supervises biological research there. His fields of interest extend to biochemistry, biophysics, bacteriology, and physiology. Recently, he has participated in studies of the application of ultrasonics and X-radiation to fields of biology. Robinson received his degree of master of science from The Ohio State University and is a member of Sigma Xi.

BIOPHYSICS, THE SCIENCE which combines both biology and physics, has aroused more interest and received more attention during the past decade than at any other time in its long history. The increasing interest in this hybrid science has resulted mainly from the great strides made in the field of nuclear physics. The application of this field to biology has intrigued investigators all over the world. With the advent of the betatron, the cyclotron, the high-voltage X-ray tube, and the need for studying the effects of atomic radiation, this phase of biophysics assumed a practical importance; and most recent biophysical investigations have been devoted to studies of this type. A study of biological effects of ionizing radiations, although very important, is only a small part of this great science of biophysics.

From the time of Galileo, who was interested in the swing of a lamp as a time-keeper to his pulse, to the present day when multimillion-volt electron generators are being developed, scientists have combined their knowledge of biology and physics fruitfully. Two hundred and fifty years ago, Borelli studied animal motion mathematically by the laws of levers. As early as 1702, physicians were interested in the mechanical aspects of biology. Richard Mead in his book on poisons wrote: "My desire in thinking of these matters was to try how far I could carry mechanical consideration in accounting for those surprising changes which poisons make in an animal body". In the nineteenth century, Tyndall, with his research on radiant energy and his part in the discussion on spontaneous generation and the bacterial origin of disease, made invaluable contributions to biophysics.

Soon after Roentgen discovered X-rays in 1895, their effects on man and microorganisms became an important biophysical problem which still remains to be solved. Although the effects of irradiation on many living materials are known, the mechanism by which the changes are made is still to be discovered.

Many physicists have attempted to apply their research findings to biology, and biologists have studied the physical principles underlying their problems. Seldom, however, have the publications of both fields of science been combined in any orderly manner. Instead, they have been scattered through the literature of both physics and biology.

The most important publication on biophysics is the voluminous work of some 3000 pages edited by Otto Glasser (1944, 1950). This work contains authoritative articles on nearly every subject that might be considered biophysical. More recent publications as "Advances in Medical Physics" (1948) and "Symposium on Applied Biophysics" (1949), have dealt mainly with the application of nuclear physics to biology.

The broad concept of the field of biophysics has been greatly confused by scientists who have attempted to limit it within the boundaries of their particular interests. Some have felt that it should comprise only a study of the fundamentals of biology such as the physical nature of protoplasm and cells, including such phenomena as viscosity, coagulation, gelation, elasticity of protoplasm, permeability of membranes, and mechanical cleavages. Others have conceived of biophysicists only as instrument makers, furnishing the tools for measuring the complex processes and structures of living organisms. Still others suggest that the mathematical approach to the solution of biological problems is the main purpose of biophysical studies. Finally, there are those who feel that the application of known physical phenomena to explain the behavior and structure of biological mechanisms is the true field of biophysics. In its broadest sense, biophysics includes all of these fields of interest and others. It is the physics of living organisms in all its branches.

The valuable contributions of biophysics have been widely recognized. Discoveries and developments in this field have already added invaluable information

of a practical nature, and theoretical studies are helping to complete the picture of various biological complexities.

All Physics Fields Contribute

The optical microscope, one of man's most ingenious accomplishments, represents the application of physical principles to assist the biologist. In later years, still greater barriers to seeing the invisible were overcome by substituting streams of electrons for the beam of light, in the electron microscope. The application of the principles of optics has made possible such instruments as the bronchoscope with which one can visually explore the lungs. Optical principles also assist the fundamental scientist in identifying components in electrophoretic and ultracentrifugal analysis. The small components that are separated by these methods are identified by their absorption of ultraviolet light or by their refractive index. Those who wear glasses are constantly aware of the biological importance of optics.

We could range through nearly all the branches of physics and quote many examples of the contribution of biophysicists to a better understanding of life. By virtue of high intensities and possible short wave lengths, physicists using ultrasonics have accomplished certain previously impossible physical tasks. Microorganisms can be broken up or killed with a minimum of change in the materials which make up the living cells. Earlier techniques for the fragmentation of living cells often resulted in mechanical or thermal denaturation of important unstable protein cell constituents. It now appears that "pure" fractions of some of the complex materials in cells may be obtained and studied by disrupting the cells with ultrasonic energy and separating the fractions in an ultracentrifuge. Medically, ultrasonic energy has also been used for treating neuralgia, locating foreign substances in the body or tumors in the brain, and disintegrating gallstones.

The laws of the physics of gases have been used to develop devices for the protection of aviators flying at high altitudes and divers descending to greater depths in the sea. They may, in time, help men to travel safely in space.

Applications of electrical physics have been of major importance to biologists. For example, it has produced instruments such as the electrocardiograph, which records small voltages due to the beating heart, and the electroencephalograph, which records the electrical activity of the brain. Electrical physics will add much more to fundamental biology when very small electrical potentials in living matter can be measured.

An understanding of the effects of electromagnetic fields on organisms would result in a much fuller understanding of "life". Radiations from several segments of the spectrum are known to have important biological applications. The ultraviolet radiation of blood has a bactericidal effect in that it stimulates white blood cells to engulf bacteria in the blood stream. Furthermore, it has been demonstrated that ultraviolet radiation can increase the oxygen absorption in blood by 60 per cent. In microscopy, ultraviolet light increases the resolving power and reveals, without staining, structural details of specimens which show differential absorption in the ultraviolet but not in the visible portion of the spectrum. The chemical constituents of the cell thus show up as different colors, and the sharply-defined boundaries between these colored areas give a clear picture of the cell structure.

The value of infrared radiation has been established, especially in photomicrography. Cell structure of botanical specimens can be studied better in infrared light because cell walls and contents are more transparent to infrared than to visible light.

The use of X-rays in medical radiology is one of the best known contributions of biophysics. The biological effect of the rays has been studied for over 50 years, yet we still consider X-rays a mysterious agent in the treatment of malignant growths. The exact effect of the X-rays on single cells is not known. When we have learned more about the reaction of certain cell components to X-rays, the administration of selective lethal dosages may be possible. This would increase immeasurably the medical and industrial value of X-radiation.

Bioclimatology

Bioclimatology, one of the oldest sciences, deals with the action of the physical world on living things. Geographic environments work on organisms through factors of the atmosphere, and physiological effects result from the meteorologic elements, such as pressure, humidity, amount of solar radiation, etc., which compose it. The manner in which these environmental factors work collectively is not always clear. That they affect human behavior can be testified to by biologists who find their research subjects under certain climatic conditions reacting in a manner which can be explained by no other means. Certain salesmen make a practice of visiting their customers only on those days when they consider that the weather conditions favor an optimistic, receptive mood in the customer. Regardless of the mild or moderate susceptibility which organisms may show to climatic influence, a greater knowledge of the mechanism should be worth while.

Physical instrumentation can be a major contribution of the biophysicist. In recent years, electronics has become a science in its own right. Many biological measurements which previously were not possible because

of inadequate methods for amplification and recording can now be made electronically.

A good example of biophysical instrumentation is the cantilever microtome developed recently at Battelle. This microtome is unique in ability to prepare serial sections of plant and animal tissues 1/10 of a micron in thickness. The smaller cellular inclusions can be studied better in very thin sections because transparency is greatly increased and distortion of cellular components is decreased. Other intruments, such as mechanical pumping systems, are being developed to perform temporarily the functions of heart, lung, and kidney. Although such "artificial" organs have been widely used on animals, they are not generally available for use on human subjects. When the designs of such devices have been proved and standardized, new methods of surgery may develop. Other new or potential developments in "medical engineering" are designed to aid biological research. For example, automatic counting devices for routine examination of slide smears for cancer cells show promise of speeding up this tedious process. Larger numbers of samples might be examined, and early diagnosis of cancer might be aided without the tremendous labor usually required by visual counting. Similar equipment is under development for counting red blood cells.

No biologist can have a real knowledge of the structure of living things without a background in mechanics, strength of materials, effects of accelerations, coefficients of elasticity, etc. As the air age advances, more detailed information is necessary on the effect of forces on humans during dive pull-outs or high-speed turns. To overcome human tolerance limitations to acceleration, special pneumatic suits have been designed which stop the flow of blood through certain arteries and veins by means of pneumatic cuffs. Hydrostatic measurements had to be made on the blood in the heart-to-head column, and the functions of the retina and the brain had to be determined under increased or decreased blood pressures.

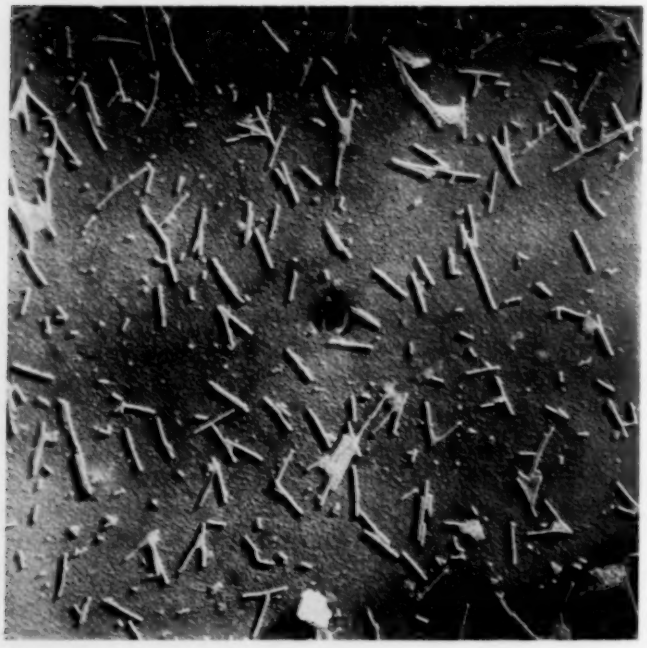


Figure 1. Electron micrograph of Tobacco Mosaic Virus, platinum shadowed at an angle of 12°, showing partial fragmentation of the virus with ultrasound. These virus particles were irradiated for five minutes at a frequency of seven megacycles per second and an input intensity of 180 watts. The length of the virus before fragmentation is 280 millimicrons. 46,800 X.

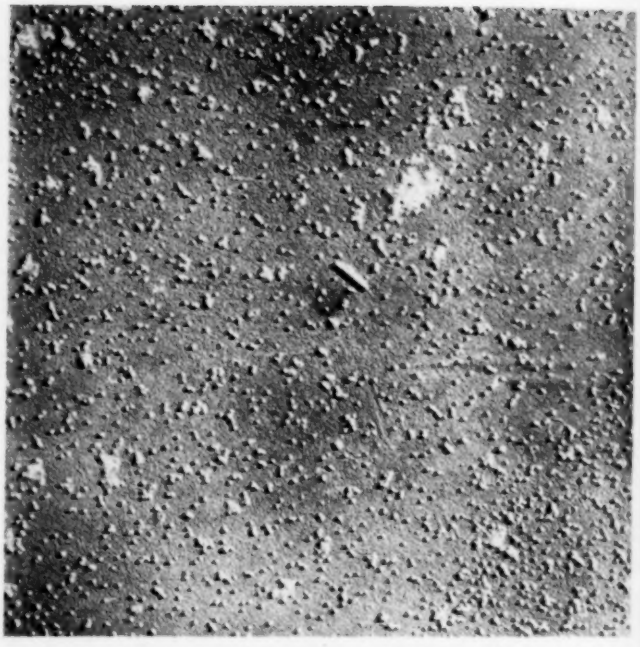


Figure 2. Electron micrograph of Tobacco Mosaic Virus, platinum shadowed at an angle of 12°, showing extreme fragmentation resulting from ultrasonic treatment. Many of the particles shown measure from 20 to 40 millimicrons (.8 to 1.6 millionths of an inch) in length. Preliminary tests have indicated that the protein fractions of these virus particles were not denatured by ultrasonic fragmentation. The virus was treated for three minutes at a frequency of seven megacycles per second and an intensity of 220 watts input. 46,800 X.

Studies in thermodynamics also play a great part in facilitating high-altitude flying. Biophysical studies on heat losses from the body's skin surface led to the development of materials and clothing that now enable human beings to work efficiently and comfortably at subzero temperatures which previously were unbearable.

Research in aeromedicine has contributed to our knowledge of dark adaptation, standards for night vision, cockpit lighting, acclimation to altitude and motion sickness, land survival, and the ability to withstand ultrasonic and mechanical vibrations. Although the biophysicist must commonly study the mechanics of living matter on a large scale, he will also make contributions in the theoretical and experimental de-

termination of the role of molecular and atomic structure in the production of physiological events.

Nuclear Biophysics

Obviously, the role of nuclear physics in biology is a large and important one. Recently, artificially induced radioactivity, in the form of radioactive isotopes, provided the physiologist with a new means of studying metabolic processes. It is well known in biology, for example, that certain dyes are selectively absorbed by certain tissues. Attempts to combine radioactive chemicals with these dyes to locate malignant tissues or to treat malignant tissues have offered some promise in the field of cancer therapy. For example, this method is being successfully used for locating tumors in the brain. A small Geiger counter is inserted into the brain during the operation.

Radioactive isotopes have enjoyed extensive and increasing use in biological research. When atoms of many elements are bombarded with high-speed particles, neutrons, protons, deuterons, etc., the element undergoes nuclear reactions. If the isotope thus produced is unstable, it spontaneously disintegrates, gives rise to a new element, and frequently gives off radiation of the same wave length and character as X-rays. The concentration of the unstable isotope can be determined by appropriate methods, and if a compound tagged with the isotope is fed to an organism having physiological processes which do not distinguish between molecules containing different isotopes of the same element, the tagged molecules may be followed through the intricate paths involved in nutrition. In this way, more and more information is being obtained on the physiological reactions of plants and animals.

The effects of nuclear radiations on living matter are problems which the biophysicist must answer in view of the catastrophic effects which another war might bring. Emphasis must be placed on finding substances that inhibit the effects of nuclear radiation. To date, two have been reported, but both appear to be of limited value. In view of an atomic power age, the biophysicists are required to evaluate the hazards in handling radioactive materials and to search for new biological uses of radioactive waste products.

The fact that living organisms can be killed by radiation presents many possibilities for industrial application of fission products. An important industrial advantage of irradiation is that it not only kills living organisms, but does not produce an appreciable temperature rise in the material treated. Potential industrial uses for fission products include the sterilization of drugs, pharmaceutical and medical supplies, and foods. It is possible that fission products in the quantity necessary for industrial use may not be available before five or ten years; however, considerable research has already been completed on their adaptability to cold sterilization.

It is evident that biophysics covers a large field of research and can make great contributions to biology and human welfare. This combination of the sciences of physics and biology is not a particularly simple one. Physicists deal for the most part with phenomena that can be exactly measured, under completely controlled conditions. The biologist, on the other hand, must deal with life, with all of its unmeasurable attributes. It is certain that the materials of living organisms are much more complex than those ever before subjected to physical inquiry. Studies on these complex biological mechanisms show that they may react in various and unsuspected ways. Physicists who deal in their research, generally, with traceable patterns of cause and effect certainly find the unpredictable reactions of biological mechanisms disconcerting to say the least. Close cooperation between the biologist and physicist, however, can result in marked advances in our knowledge of living organisms and the phenomenon called life.

It is clearly our duty as citizens to see that science is used for the benefit of mankind. For, of what use is science if man does not survive?

—Duke of Edinburgh, Presidential Address before the British Association of Scientists.

Industry and the Water Problem

by CLOYD A. SNAVELY

His work in metallurgy and electrochemistry carried Dr. Snavely naturally into research on problems of the disposal of industrial wastes and stream pollution and led to his interest in industry's need for an adequate supply of water. His published articles relate to chromium plating, the cleaning of metals, and the treatment of industrial wastes. Before joining Battelle in 1945, Dr. Snavely served as Laboratory Supervisor for the U. S. Navy at Norfolk, Virginia.

MAINTENANCE OF AN adequate water supply is a problem that concerns much of American industry. Industrial installations depend upon water for cooling systems, processing of products, and boiler feed, as well as for sanitary and other service purposes. Use of water in industry accounts for at least one-fourth of the Nation's total consumption. This is double the amount used for general municipal purposes.

Water supply has become more critical in recent years. Shortages have occurred in various parts of the country where the supply had previously been taken for granted. This has caused leaders in industry and government to re-examine present water-use practices and to study the potentials for increasing water supply and for making it more reliable.

Shortages of water have been brought on by a steady rise in its consumption without, at the same time, an adequate conservation program and systematic planning for the replacement of supply. Expansion in the scale of industrial operations, population shifts from rural to urban aras, greater use of water-consuming home appliances, air conditioning, and more irrigation projects all have contributed to higher water consumption. Use of water by industry has increased about 40 per cent in the last ten years. At least one authority has predicted that industrial usage of water will double during the next decade.

In the midst of apparent water scarcities, it is interesting to learn from the President's Water Resources Policy Commission just how large the country's water resources are. "The total quantity (of water) in constant circulation, measured in precipitation, amounts to about 4300 billion gallons daily. This is roughly ten times the average flow of the Mississippi River.

"Some 3000 billion gallons a day, on the average, return to the atmosphere as a vapor, through evaporation and transpiration (use by vegetation). This leaves the annual runoff to the sea at an average of about 1300 billion gallons a day." At the present time, the country captures and uses only 100 to 200 billion gallons daily from this runoff.

The development of the country's tremendous water resources potential is a long-range project. Government and interested industrial leaders are giving it serious attention. The development involves a wide variety of interrelated projects such as flood control, irrigation, surface-and ground-water development, and better management of streams, forests, and lands. The study includes new sources of fresh-water supply, such as the ocean and artificial rainmaking.

WHAT INDUSTRIES ARE DOING

For the immediate future, industry can go a long way toward solving its water-supply problems by making more efficient use of existing water supplies. Principally, this means pollution abatement and increased re-use of water.

An industry-wide survey by the National Association of Manufacturers shows that two out of five of the plants they contacted reuse at least some of the water taken in. In recent years, the survey points out, "some of the large users, notably paper, petroleum, textiles, chemicals, and steel, have made enormous progress in developing water circuits for the use of water in more than one plant process. For example, one chemical concern reports that by recirculating its water it has reduced process water requirements from 130 million gallons per day to 4 million gallons per day. A steel mill in Ohio reuses drainage from drinking fountains and filter wash water."

The purification of waste water that goes into streams can greatly increase the supply of water suitable for downstream industrial or municipal use. This is now an important factor in the industrial develop-

ment of some areas where otherwise adequate raw materials and labor supplies exist.

Methods are being devised for the treatment of wastes that formerly went into streams untreated. The petroleum and metal-finishing industries have necessarily taken the lead in this effort. The pulp and paper industry is also giving serious attention to its waste problem. In many cases, proper treatment methods are well established, but economic considerations have slowed the installation of treatment facilities. This is equally true of industries and municipalities.

Developing Water Resources

Many industrial plants and all domestic consumers are concerned with the quality as well as with the quantity of water available. It would be helpful to industry in some locations if streams were free of domestic sewage. This has given rise to considerable research on the more extensive development of underground water. It is usually cleaner and freer from contamination than river water.

Underground water reservoirs have been overworked in many parts of the country, without adequate thought given to their replenishment. It is estimated, however, that they provide the greatest fresh-water-storage facilities in the United States, even larger than those of the Great Lakes.

Recharging or restoration of underground water resources has been practiced successfully on the Pacific Coast, and in such localities as Louisville, Kentucky and Des Moines, Iowa. The practice will become more extensive as more is learned about the technique of recharging, and as its advantages become more widely appreciated.

Another aspect of the water-use picture is the need for increasing recreational facilities near industrialized communities. The same forces that concentrate groups of people in restricted industrial areas make it difficult and costly to provide adequate outdoor recreation. Industrial leaders are increasingly recognizing the importance of outdoor recreation in the everyday life of the nation's working force. Recreational use of water puts an added burden on municipal and industrial pollution-control efforts.

Scientific research has an important role in all phases of future water-supply development. Discovery and evaluation of underground water involves the geologic sciences. Artificial rainmaking involves the techniques of the physicist and meteorologist. New methods for purifying water involve the physicist and chemist. A relatively new research product based on organic chemistry is the permion diaphragm. It is too early to evaluate this development accurately, but the new product is potentially the most important water-treatment development since the advent of chlorination. Fresh water from sea water at nominal cost may be within man's grasp through the use of this development. The science of permion diaphragms is not new, but new types of such diaphragms are now available and are being studied for numerous industrial applications including water treatment.

During recent years, recurring shortages of water in various parts of the country have caused the nation to take inventory of its water resources, and to re-examine present water-use practices. One fact stands out above all the rest. A great need exists for conservation and development of the country's tremendous water resources. This is necessary to insure an adequate, reliable supply of fresh water to industry and all other parts of the economy.

Less than one-half of one per cent of the inhabitants of the United States are professionally engaged in scientific research, the technological application of its results, and the teaching of science. These scientists share the responsibility for human welfare with all other citizens. They cannot, however, escape the fact that because of their intellectual powers and their influence in forming public opinion, theirs is a larger share of that responsibility than their numbers alone would indicate.

—Kirtley F. Mathu, "The Common Ground of Science and Politics" in *Science*.

Notes From Battelle

VALUE OF EXCESS POLYOL IN ALKYDS

Improving the viscosity, drying, hardness, and other qualities of varnishes is the constant goal of the coatings industry. One of the methods for accomplishing this is to increase the amount of maleic anhydride in the cook. However, the addition of large amounts of the material often causes serious difficulties, especially in the seeding-out of small gelled particles in the vehicle.

Research at Battelle has pointed the way to a possible solution for this problem of maleic additions. Coatings technologists there have discovered that adding an excess of polyol beyond that needed to react with the acidic ingredients of maleic-tall oil alkyds overcomes the difficulty. They experimented with a 0 to 25 per cent excess of glycerol and a 0 to 10 per cent excess of pentaerythritol. These additions resulted in marked improvement in the bodying rate of the alkyds while having little or no effect upon their film, drying rate, adhesion, or cold-water resistance qualities.

A glycerol-maleic alkyd using 9.5 per cent maleic anhydride needs a 20 per cent excess of glycerol to reach gelation. Pentaerythritol, on the other hand, requires no excess to reach the same stage. The lower effectiveness of the glycerol is attributed to hydrolysis with resulting glycerol loss. It was found under experimental conditions that the bodying rate of 10 per cent excess pentaerythritol is about equal to that of 20 per cent excess glycerol alkyds.

The results of the investigation suggest that excess polyol can be a useful tool for controlling the cooking time, viscosity, and acid number relationship of the finished vehicle.

COPPER-BERYLLIUM ALLOY SUBSTITUTE

Beryllium, a metal of growing importance, has been close to being on the critical list in recent years. This situation has existed because beryllium-bearing ores are shipped from Brazil and South Africa, and also because the metal is important in the atomic energy program.

Industrially, beryllium is important in the production of precipitation-hardenable copper-base alloys. The International Business Machines Corporation has used a copper-beryllium alloy for many years as electrical spring contacts in its large business machines. Desiring to be prepared for a possible beryllium shortage, the corporation asked Battelle to search for a new alloy to replace the copper-beryllium now in use.

After preliminary study, the copper-nickel-silicon base alloys were selected as the most promising point at which to begin research. Various materials for addition to these alloys were investigated with the discovery that aluminum added valuable properties. Large experimental heats of four promising alloys were then prepared. After investigating the qualities of strips of the metal that had been solution-treated and aged at different temperatures and for various periods, Alloy A 114 was discovered to be entirely adequate for the required purposes.

Alloy A 114 is an age-hardening copper-base alloy containing about 10 per cent nickel, 1.5 per cent silicon, and 4 per cent aluminum. It can be readily formed in the solution-treated condition and can be age-hardened to the following properties: yield strength—120,000 psi; tensile strength—140,000 psi; elongation—8 per cent; proportional limit—85,000 psi; modulus of elasticity—19 million psi; and electrical conductivity—11 per cent of copper. Cold work before aging treatment will improve the alloy's properties.

Alloy A 114 appears to be a possible replacement for copper-beryllium alloys except for certain applications. For example, where the latter is heat treated in certain ways it has extremely high tensile strength.

COPYRIGHT PROTECTION FOR SCIENTISTS

On September 6, 1952, a Universal Copyright Convention or agreement was signed at Geneva, Switzerland, by 35 nations, including the United States. It is scheduled for presentation to the United States Senate during the current session.

In signing the document, the subscribing nations declared that they were "moved by the desire to assure in all countries copyright protection in literary, scientific, and artistic works." Moreover, they agreed to provide for the "adequate and effective protection of the rights of authors and other copyright proprietors in literary, scientific, and artistic works."

The following are the provisions of the new Convention that have particular importance for workers in scientific fields:

1. The term "copyright" is defined as including the author's exclusive right to make, publish, and authorize the making and publication of translations of works protected under the Convention.

2. The term "publication" is defined as "reproduction in tangible form and general distribution to the public of copies of a work."

3. The setting up of a procedure which makes it possible for citizens of subscribing states to obtain a nonexclusive license to publish a work in any national language of the state into which it has not been translated after seven years from the date of first publication.

The new Convention is intended to supplement existing international copyright agreements. It is repeatedly pointed out in the text that the new Convention shall not in any way affect the provisions of copyright conventions already in effect.

PUTTING IDEAS TO WORK

Ideas for technical development serve no one until they are put to work. Yet it is frequently difficult for a free-lance inventor or for research workers in universities and industry to find a way for developing their creative ideas.

Corporations, as well as individuals, lose opportunities for economic gain by letting ideas lie idle. Corporations may occasionally hold patents obtained during the course of their research that are outside their manufacturing interest. Unless these patents are licensed for use, the owners and the public receive no benefit from them.

The Battelle Development Corporation is an instrument for putting such ideas to work. It is a wholly owned not-for-profit subsidiary of Battelle Memorial Institute and owns, according to Russell L. Deubner of its staff, 226 United States and foreign patents, and 270 patent applications. It also has an interest in 35 other patents and patent applications.

A booklet, "Putting Ideas To Work", is now available from the Battelle Development Corporation.

TITANIUM-CHROMIUM ALLOYS

The development of high-strength titanium alloys is an important factor in the improvement of aircraft. In this connection, an extensive titanium-alloy development program is being carried out at Battelle for Wright Air Development Center. One aspect of this program has been the study of the constant-temperature transformation characteristics of several titanium-chromium alloys.

In the study, alloys were heated to 950 C (the beta range) and then quenched in a lead bath and held at constant temperatures ranging from 450 C to 650 C for varying lengths of time while transformation took place. The actual study is concerned with the phases of the material and the hardness of the specimens after these isothermal treatments. The resulting information has been of considerable help in selecting heat treatments for various alloys.

In their paper, "Isothermal Transformation of Titanium-Chromium Alloys", which was presented before the recent Western Metals Congress, Battelle metallurgists Paul Frost, W. M. Parris, and L. L. Hirsch and physicists J. R. Doig and C. M. Schwartz reported on one phase of the work. They discussed the determination of the time-temperature-transformation diagrams for titanium-chromium alloys containing 7.54, 4.64, and 2.35 per cent chromium. They also reported that during these studies, a new phase, which they have tentatively called the "omega" phase, was discovered.

The investigations indicate that the omega phase may be partly responsible for hardening in beta-phase titanium as well as for the embrittlement that occurs when alpha-beta or beta alloys are exposed to moderately elevated temperatures.

ZIRCONIUM, IRON, AND TITANIUM

The importance of zirconium in nuclear applications has increased interest in its high-temperature properties. However, since only small amounts of the metal are available, the study of its metallurgy has been slowed up. In the face of this situation, the development of methods for speeding up research on zirconium is important at this time.

Arthur D. Schwope, who directs much of the metals research at Battelle, presented a useful method for advancing zirconium research before the Western Metals Congress at Los Angeles. His paper, "A General Comparison of the Metallurgy of Zirconium with That of Better Known Commercial Metals", discusses the similarities of zirconium, iron, and titanium. Because of these similarities, he points out, metallurgists can often use their knowledge of the behavior of iron and titanium to guide their study of zirconium.

On the basis of observation and experience, similarities are seen in the allotropic transformation of the three metals as well as in their alloying properties. It has been possible to work out a method of predicting the effects of minor alloy additions to zirconium. Furthermore, metallurgists may predict the effects of alloying on the equilibrium diagram and the high-temperature strength of zirconium on the basis of experience with iron and titanium. Through such comparisons, it has been possible to speed up zirconium research.

RECENT PAPERS AND ARTICLES BY THE RESEARCH STAFF*

Preparation of Coal in the United States in Relation to Its Use. R. B. Engdahl and A. C. Richardson. Fourth International Congress on Industrial Heating, No. 142, Paris, 1952.

A Study of the Principles of Gating as Applied to Sprue-Base Design. K. Grube, J. G. Kura, and J. H. Jackson. *Transactions of the American Foundrymen's Society*, 1952.

Microstructure and Mechanical Properties of Iodide Titanium. F. C. Holden, H. R. Ogden, and R. I. Jaffee. *Journal of Metals*, February, 1953.

High-Temperature Corrosion in Power Station Boiler Furnaces and Superheaters. J. H. Jackson. Fourth International Congress on Industrial Heating, No. 144, Paris, 1952.

The Foundryman Looks at Air Pollution. N. H. Keyser and H. P. Munger. *Transactions of the American Foundrymen's Society*, 1952.

How Iron and Steel Melt in a Cupola. H. W. Lownie, Jr., D. E. Krause, and C. T. Greenidge. *Transactions of the American Foundrymen's Society*, 1952.

Titanium-Manganese System. D. J. Maykuth, H. R. Ogden, and R. I. Jaffee. *Journal of Metals*, February, 1953.

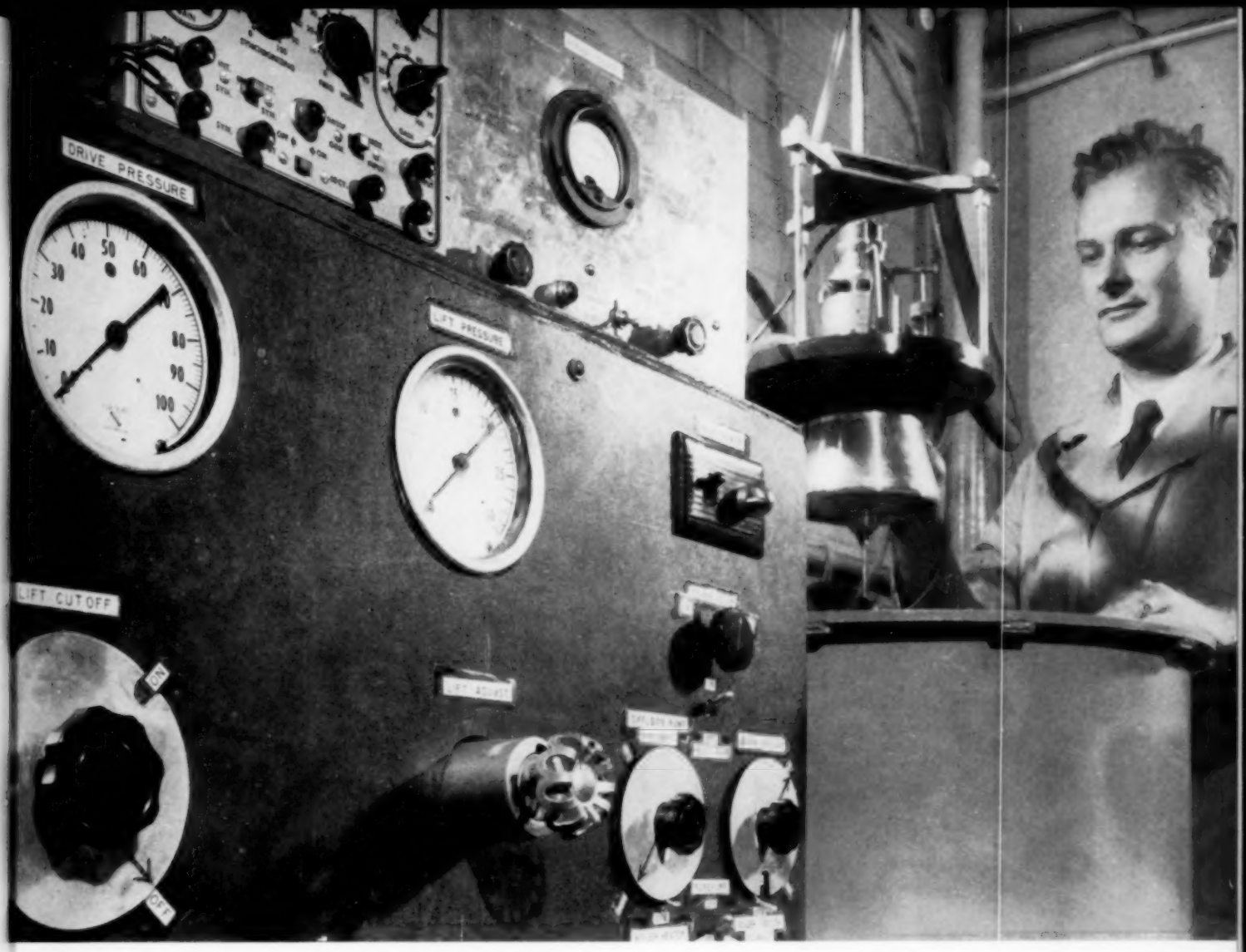
Titanium-Tungsten and Titanium-Tantalum Systems. D. J. Maykuth, H. R. Ogden, and R. I. Jaffee. *Journal of Metals*, February, 1953.

Mechanical Properties of High Purity Ti-Al Alloys. H. R. Ogden, D. J. Maykuth, W. L. Finlay, and R. I. Jaffee. *Journal of Metals*, February, 1953.

Low-Temperature Aging in Titanium Alloys. W. M. Parris, L. L. Hirsch, and P. D. Frost. *Journal of Metals*, February, 1953.

Ball Milling of Pure Ceramic Bodies. H. Zane Schofield. *American Ceramic Society Bulletin*, February, 1953.

*In most cases, reprints will be available from the Battelle Publications Office upon request.



ULTRACENTRIFUGE

Liquids placed in that hat-shaped container on the right of the photograph can be whirled at a speed of 60,000 revolutions per minute, giving a force equal to 200,000 gravities. This ultracentrifuge at Battelle can be used to isolate viruses, proteins, or polymers down to 10,000 millimicrons. It can also be employed to measure and determine shapes of molecules. The equipment is useful in the characterization of human, animal, and plant proteins, in the study of blood proteins, and for investigations in the fields of physical and colloidal chemistry.

BATTELLE INSTITUTE was founded by the will of Gordon Battelle as a memorial to the Battelle family. The Battelles were among the first settlers of Ohio and were prominent in the development of the state's iron and steel industry.

Gordon Battelle, last of the family line, was impressed with the benefits to be derived from industrial research and left his estate for the building and endowment of an Institute "for the purpose of education . . . the encouragement of research . . . and the making of discoveries and inventions for industry." The Institute began operations in 1929.

As established Battelle provides, on a not-for-profit basis, the physical plant, equipment, and personnel for conducting research. The great bulk of it is applied research conducted for industry and government.

In keeping with its educational function, the Institute also conducts fundamental or basic research. The results of much of this research are published for the general encouragement of science and industry, and to benefit the public welfare.

Fields of research at Battelle include agriculture and practically all the industrial and engineering sciences.

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